WORKING PAPER 80-4

PROSPECTS FOR REDUCED OIL CONSUMPTION IN CANADA

W. R. FRIEDENBERG
A. J. NIXON

MAY 1980

Working papers are distributed by the Canadian Energy Research Institute in limited numbers. They represent the results of work in progress and are made available in this preliminary form both for information and to obtain comments.

1982-02-05

ERRATA - WORKING PAPER 80-4

km^3 should be $10^3 m^3$;

Mm^3 should be $10^6 m^3$, throughout.

CONTENTS

FIGURES.....iv

TABLES.....iv

INTRODUCTION.....1

APPROACH.....2

CANADA'S CURRENT OIL CONSUMPTION.....3

FACTORS AFFECTING ENERGY AND CRUDE OIL DEMAND.....4

'70s TREND' FORECAST.....6

THE IMPACT OF HIGHER DOMESTIC OIL PRICES.....8

NATURAL GAS PIPELINE EXPANSION.....16

GOVERNMENT LEGISLATED CONSERVATION PROGRAMS.....18

SUMMARY AND CONCLUSION.....24

APPENDIX A: ESTIMATES OF PRICE ELASTICITIES BY FUEL TYPE AND END USE SECTOR.....31

APPENDIX B.....34

FIGURES

1 Forecast Levels of Oil Consumption, 1979 - 2000.....26

2 Relative Fuel Shares, 1979 and 2000.....28

TABLES

1 Canadian Oil Consumption 1979.....3

2 Canadian Oil Consumption, Oil Prices and Real GNP 1972-1979.....7

3 Forecast Average Annual Growth Rates in Oil Consumption Under Higher Domestic Oil Price Increases.....10

4 Percentage Shares of Energy Fuels in Total Energy Consumption.....11

5 Forecast Growth in Oil Consumption and Relative Fuel Shares Assuming Higher Oil Prices (1980 - 2000).....13

6 Possible Savings in Oil Consumption through Higher Oil Price Increases 1985, 1990, 2000.....14

7 Savings in Oil Consumption Due to Natural Gas Market Expansion.....16

8 Conservation Programs and Possible Energy Savings in the Canadian Economy.....19

9 Possible Savings in Crude Oil Consumption Due to Conservation Measures 1985, 1990, 2000.....22

10 Savings in Canadian Oil Consumption 1985, 1990, 2000.....25

A.1 Estimated Own-Price Elasticities by Fuel Type and End Use Sector.....32

B.1 Possible Savings in Oil Consumption through Higher Oil Price Increases 1985, 1990 and 2000.....34

Acknowledgements

We would like to thank the support staff who patiently and efficiently worked on a number of draft manuscripts. This paper also benefited from the advise of two referees who remain anonymous.

We remain responsible for any errors or omissions.

INTRODUCTION

The sharp increase in world oil prices since 1973-74 and the continued threat of embargo have increased the need for oil importing countries such as Canada to decrease their consumption of oil products.[1]

The purpose of this paper is to analyze Canada's prospects for reduced oil consumption between now and the year 2000. Canada's supply of oil at some future date, for example the year 2000, can be increased by discovering and developing more oil reserves over the next 20 years and/or by consuming less oil between now and the year 2000. This paper indicates that there is a large potential for increasing Canada's future oil supply through reducing Canada's growth rate in oil consumption. The prospects for reducing Canada's growth in oil consumption, discussed in this paper, in combination with forecasts of oil discoveries will throw light on the question of whether or not Canada can become self-sufficient in oil before the end of this century.[2]

The potential for reducing Canada's oil consumption depends critically upon government legislation. The price of oil, the expansion of Canada's gas pipeline system, and conservation programs, three important variables influencing Canada's oil consumption, are all subject to government legislation. It is very difficult to forecast what government legislation will be with regards to these three variables. This paper indicates the magnitude of oil consumption savings that are possible under one assumed scenario about future oil prices, gas pipeline expansion, and legislated conservation programs.

APPROACH

We begin the analysis by briefly discussing Canada's current oil consumption and the factors which affect the demand for total energy and crude oil. This is followed by a projection of the future growth rate in Canadian oil consumption under the main assumption that the $\$12.60/m^3$ ($2/bbl) per year increase in the domestic oil price established during the late 1970s is continued. The forecast growth rate in oil consumption under this assumption is called the '70s Trend' forecast. We then discuss the savings in oil consumption that are likely to arise if domestic oil prices are increased at a rate significantly above $\$12.60/m^3$ ($2/bbl) per year. Following this we analyze the savings in oil consumption through expansion of Canada's gas pipeline system. Finally we indicate some possible savings that could arise through government legislated conservation programs. The conclusion summarizes and comments on the overall findings of the analysis.

CANADA'S CURRENT OIL CONSUMPTION

Table 1 shows 1979 oil consumption by region. Canada is currently consuming about 301 thousand cubic metres per day (Mm^3/d) of refined petroleum products. Canada imports approximately 79 Mm^3/d (500 Mb/d) of crude oil into eastern Canada which represents about 25 percent of domestic oil consumption. Canada exports approximately 48 Mm^3/d to the United States.[3] The Atlantic region is entirely dependent on imports to meet its oil requirements. Quebec relies on oil imports to meet 35 percent of its requirements which currently total about 82 Mm^3/d.

TABLE 1

CANADIAN OIL CONSUMPTION 1979
(Mm^3/d)

Region	Domestic Consumption of Refined Petroleum Products	Crude Oil Imports
Atlantic	38.7	50.6
Quebec	82.1	28.6
Ontario	98.6	-
Prairies & Northwest Territories	51.7	-
British Columbia	29.8	-
CANADA	300.9	79.2

SOURCE: Canada, Statistics Canada, Refined Petroleum Products, Catalogue No. 45-004.

NOTE: 1 cubic metre (m^3) = 6.293 barrels

FACTORS AFFECTING ENERGY AND CRUDE OIL DEMAND

In order to determine the factors affecting energy demand, the standard approach is to begin by disaggregating the economy into various subsectors (i.e., residential, commercial, industrial and transportation, or intermediate and final domestic, and export demand). Empirical work has revealed that price is certainly a large determining factor of energy demand in the various subsectors. The reader is referred to Table A.1, in Appendix A, for estimates of own-price elasticity for total energy demand as well as for specific fuel types.[4] One can see from the table that the elasticity estimates for total energy are generally lower than those for the individual fuels as the availability of substitutes for energy per se are more limited than for any one fuel type.

Another important factor affecting energy demand is the level of economic activity in the economy as a whole or in each subsector if one is taking a disaggregated view. Real Gross National Product (GNP) is the economic indicator often used to measure this factor. In a sectorial analysis, however, a measure of real domestic product in a specific sector is the preferred economic indicator. A sectorial analysis allows the analyst to assume different levels of economic activity in each subsector of the economy rather than relying on a single measure of the overall level of activity such as the Gross National Product. Although GNP is an important determining factor of the level of energy consumption, forecasting energy consumption on the basis of an historic ratio between GNP and energy consumption is only a valid procedure under conditions of constant relative prices or non-responsiveness to changes in relative price levels. Since we know that relative prices change and that consumers are responsive to these changes, simply projecting energy demand on the basis of energy consumption-GNP ratios would likely lead to unreasonable energy demand forecasts. As the

relative price of energy increases one would expect to observe future economic growth becoming less energy intensive.

There are other factors which also play a determining role in the level of energy demand such as tastes, disposable income and its distribution, number of households and their spacial location, and technology.

If one were to look at the demand for a specific fuel type, particularly crude oil, one could outline its determining factors with even greater precision. Price is very important in determining the level of consumption as well as the price of competing fuel types such as natural gas and coal. Technology is another important factor as it affects crude oil consumption, especially in the transportation sector where the degree of price responsiveness is relatively weak (see Table A.1).

The existing capital stock which embodies technology is also an important determining factor of crude oil demand. One can, for example, envisage a set of relative fuel prices under which a proportion of the demand for a specific fuel type is 'captured' in the sense that it is not economic to convert the capital stock to the use of an alternate fuel type.

'70s TREND' FORECAST

Table 2 presents 1970s time series for domestic oil consumption, domestic oil prices (real and nominal), and real GNP. Canada's average annual growth rate in oil consumption between 1972 and 1979 was 2.5 percent. This is much less than the 3.7 percent average annual growth rate in GNP over the same period.

Canada's average annual oil price increased from $\$18.25/m^3$ ($\$2.90/bbl$) in 1972 to $\$83.38/m^3$ ($\$13.25/bbl$) in 1979. Adjusted for inflation (stated in terms of 1971 dollars) the 'real' price of oil increased from $\$17.40/m^3$ in 1972 to $\$43.88/m^3$ in 1979. During 1979 the increase in Canada's oil price was less than Canada's rate of inflation. As a result the real price of oil fell to $43.88 from the 1978 level of $44.03.

If Canada were to continue increasing its oil price at around $\$12.60/m^3$ ($\$2/bbl$) per year, we believe an average growth rate in oil consumption of 2.5 to 3.0 percent to the year 2000 would not be an unrealistic expectation. Implicit in this expectation is a forecast growth rate for real GNP averaging around 3 percent and inflation continuing at around 9 percent. We have chosen to call the 2.5 to 3.0 percent growth rate in oil consumption the '70s Trend' forecast since it essentially extrapolates from Canada's experience during the 1970s.

TABLE 2

CANADIAN OIL CONSUMPTION,
OIL PRICES AND REAL GNP
1972 - 1979

Year	(1) Domestic Consumption of Refined Petroleum Products (Mm^3/d)	(2) Average Domestic Crude Oil Price ($\$/m^3$)	(3) Average Real Domestic Crude Oil Price (1971 $\$/m^3$)	(4) Real Gross National Product (millions of 1971 dollars)
1972	253.1	18.25	17.40	100,248
1973	262.8	27.15	24.13	107,812
1974	269.8	36.69	29.35	111,678
1975	266.3	45.94	33.17	113,005
1976	272.5	53.74	36.09	119,116
1977	277.6	64.57	40.13	121,949
1978	284.5	77.09	44.03	126,127
1979	300.9	83.38	43.88	129,658
AAGR (%)	2.5	24.2	14.1	3.7

SOURCES:
(1) Oilweek, February 11, 1980, p. 32; and Canadian Petroleum Association.
(2) A. P. Ellison, "Past and Future Energy Costs in the Canadian Economy" (Calgary: Canadian Energy Research Institute, April 1978), Working Paper 78-3, p. 89.
(3) Column (2) deflated by the Consumer Price Index, as reported by Statistics Canada Publication No. 11-003E.
(4) Gross National Product deflated by Gross National Expenditure (GNE) Implicit Price Index, Statistics Canada Publication No. 11-003E.

NOTE: 1 cubic metre (m^3) = 6.293 barrels
AAGR = Average Annual Growth Rate (1972-1979).

THE IMPACT OF HIGHER DOMESTIC OIL PRICES

Relaxing the assumption that oil prices will continue to increase at only $12.60/m^3$ per year raises the question as to what alternative price assumption to adopt. It is certainly clear that if Canada's oil price is to achieve parity with the world price within the current decade, annual increments of $12.60 will be too small. The price of oil in Canada is currently set at $92.82/m^3$ ($14.75/bbl). This compares with a price of about $CDN 220.25/$m^3$ ($35/bbl) for imported oil on Canada's east coast. At no other time has Canada's domestic oil price been so far below the world price.

To capture the impact of more rapid rates of oil price increases on oil consumption in Canada we have assumed that the domestic oil price will increase by around $31/m^3$ ($5/bbl) per year to 1985, followed by increases of $50/m^3$ ($8/bbl) per year to 1990. Between 1990 and 2000 the domestic price increases at the same rate as the world price (Canadian dollar import cost) which is assumed to increase at 11 percent per year from 1980 to 2000. Under these assumptions Canada's oil price will be around $535/m^3$ ($85/bbl) in 1990 which is 85 percent of the $630/m^3$ ($100/bbl) price for imported oil in 1990. By the year 2000 the domestic price is assumed to equal $1,517/m^3$ ($241/bbl) and the import price is assumed to equal $1,787/m^3$ ($284/bbl).

The projected 11 percent average annual increase in the world oil price reflects our belief that demand pressure on world oil supplies will support price increases somewhat above a rate of inflation of about 8 percent in western industrialized countries.[5] The annual increases assumed for Canada's domestic oil price reflect the government's stated objective of moving to higher rates of increase for the domestic price. As stated in the introduction, there is considerable uncertainty surrounding any forecast of oil prices in Canada. It is probably more difficult to forecast world oil prices

especially to the year 2000 given the political problems of the Middle East. However, given our current knowledge, the above forecasts do seem to lie within a range of reasonable probability.

There are some recent energy demand forecasts which give an indication of the rate of growth in oil consumption that Canada can expect if oil prices increase at a rate considerably above $\$12.60/m^3$ per year. Tables 3 and 4 show, respectively, oil consumption growth rates and fuel shares forecast by both the National Energy Board (NEB) and the federal Department of Energy Mines & Resources (EMR). The NEB's forecast is taken from its November 1979 Reasons for Decision report on gas exports ('medium demand' case) and the EMR's forecast is taken from its report titled, Canadian Oil and Gas Supply/Demand Overview, November 1979 ('1986 Parity' case). The oil price assumptions made for each forecast are stated in the note to Table 3.

The NEB forecast assumes that the domestic oil price increases at $\$31/m^3$ per year to 1983 after which it remains constant in real terms (i.e., increases at the rate of inflation). With these assumptions the NEB forecasts an average annual growth rate for oil consumption of around 1 percent for the various periods shown in Table 3. Comparable growth rates from EMR's '1986 Parity' case show more variation over the periods. Over the entire period 1978 to 2000, EMR forecasts an average annual growth rate in oil consumption of 0.5 percent compared to 1.2 percent forecast by the NEB.[6]

While there is a significant difference in the forecast growth rates for oil consumption between the NEB and EMR there is little difference in their forecasts of relative fuel shares. Table 4 shows that the forecast shares are very similar except for the shares assumed for coal and the 'other' (solar and wood wastes) category. The NEB assumes a lower share for coal but a higher share for 'other' fuels.

Another report which provides some indication of the growth rate in Canada's oil consumption which we might expect under higher oil price increases is the report done for the Canadian Energy Research Institute by W. Brent Friedenberg entitled Energy in Canada: Review and Outlook to 1995.[7] Friedenberg assumes that Canada's growth in oil consumption will average about 1 percent per year between 1976 and

TABLE 3

FORECAST AVERAGE ANNUAL GROWTH RATES IN OIL CONSUMPTION
UNDER HIGHER DOMESTIC OIL PRICE INCREASES
(EMR AND NEB)

	1978-1985	1978-1990	1985-1990	1990-2000	1978-2000
EMR:[a]	0.7	0.3	0.3	0.8	0.5
NEB:[b]	1.2 (1979-1985)	1.1 (1979-1985)	0.9	1.3	1.2 (1979-2000)

SOURCES: Canada, Department of Energy Mines and Resources, Canadian Oil and Gas Supply/Demand Overview, November, 1979, Table 8. Canada, National Energy Board, Reasons for Decision, November 1979, Table C-5.

[a]EMR '1986 Parity' case - assumes that the domestic oil price increases by $\$25/m^3$ per year between 1980 and 1982, and $\$31/m^3$ per year between 1982 and 1986, after which it tracks the world price. The world oil price is assumed to increase at 2 percent above the rate of increase for the U.S. wholesale price index. The domestic price of natural gas is assumed to be maintained at its 85 percent Btu parity with oil.

[b]NEB 'Medium Demand' case - assumes that the domestic oil price increases by $\$31/m^3$ per year between 1979 and 1983 achieving parity with the world oil price by 1983. World oil price is assumed to remain constant in real terms. The domestic price of natural gas is assumed to be maintained at its 85 percent Btu parity with oil.

TABLE 4

PERCENTAGE SHARES OF ENERGY FUELS IN
TOTAL ENERGY CONSUMPTION
(EMR AND NEB)[a]

	1979	1985		1990		2000	
	NEB	EMR	NEB	EMR	NEB	EMR	NEB
Oil	42	39	38	35	36	31	31
Gas	17	18	17	17	17	17	16
Coal	9	12	8	13	9	13	9
Primary Electricity	29	31	33	34	34	38	38
Other[b]	3	-	3	1	4	1	5

SOURCES: Canada, Department of Energy Mines and Resources, Canadian Oil and Gas Supply/Demand Overview, November 1979, Table 8.
Canada, National Energy Board, Reasons for Decision, November, 1979, Table C-5.

[a]Fuel shares under 'EMR' are those corresponding to EMR's '1986 Parity' energy demand projections. For oil price assumptions see notes to Table 3.
Fuel shares under 'NEB' are those corresponding to the NEB's 'Medium Demand' case. For oil price assumptions see notes to Table 3.

[b]Includes solar and wood energy.

1995 if equivalence with world oil prices is to be achieved in the early 1980s.[8] Friedenberg's forecast of fuel shares in 1995 corresponds very closely to EMR's forecast for the year 2000 shown in Table 4.

Given the above review of Canadian oil demand forecasts under the assumption of higher oil price increases, it appears highly probable that Canada could reduce its average annual rate of growth in oil consumption to about 1 percent between now and 2000 if it were to significantly increase the rate of domestic oil price increases in line with that assumed above, i.e., $\$31/m^3$ per year to 1985, $\$50/m^3$ to 1990 and an 11 percent annual increase thereafter to 2000. The growth rate in real GNP is assumed to average around 3 percent per year over the forecast period 1980 to 2000.[9]

Table 5 summarizes our forecast of the growth in Canada's oil consumption and the relative fuel shares under the above assumptions. The average annual growth rate in oil consumption could be somewhat higher than 1 percent during the 1980s, i.e., between 1 and 1.5 percent, and during the 1990s somewhat lower, between 0.5 and 1 percent. Over the whole period 1980 to 2000, the growth rate remains at 1 percent.

Under our price assumptions oil is forecast to account for 28 percent of Canada's total energy consumption in the year 2000 as opposed to 42 percent today.[10] Hydro and nuclear electricity (i.e., primary electricity) are forecast to account for 38 percent of Canada's energy consumption in 2000.[11] The substitution of hydro electricity for fuel oil in Quebec as well as other parts of eastern Canada will be a contributing factor to hydro's greater share. Coal's share is forecast to be 13 percent in 2000 as opposed to 9 percent today. One of the factors contributing to this greater share will be the substitution of coal for oil in the generation of electricity in the Maritime provinces. The share for natural gas is forecast to remain constant at around 17 percent, reflecting the assumptions that gas will continue to be priced at 85 percent Btu equivalence with oil and that there is no expansion of Canada's gas pipeline system. The next section relaxes this latter assumption.

TABLE 5

FORECAST GROWTH IN OIL CONSUMPTION AND RELATIVE FUEL SHARES ASSUMING HIGHER OIL PRICES (1980 - 2000)

	1980-1990	1990-2000	1980-2000
Average Annual Growth Rate in Oil Consumption	1.0 - 1.5	0.5 - 1.0	1.0

RELATIVE FUEL SHARES (%)

	1979[a]	1985	1990	2000
Oil[b]	42	35	32	28
Gas	17	17	17	16
Coal	9	12	13	13
Primary Electricity	29	33	34	38
Other[c]	3	3	4	5
	100	100	100	100

[a]Canada, National Energy Board, Reasons for Decision, November 1979, Table C-5.
[b]Includes Liquified Petroleum Gases (LPG).
[c]Includes solar and wood energy.

Table 5 Assumptions:

(i) The domestic oil price increases by around $\$31/m^3$ ($5/bbl) per year to 1985, followed by increases of $\$50/m^3$ ($8/bbl) per year to 1990. Between 1990 and 2000 the domestic oil price increases at an average annual rate of 11 percent.

(ii) The world oil price (Canadian dollar import cost) increases at an average rate of 11 percent per year from 1980 to 2000.

(iii) Real GNP grows at an average annual rate of 3 percent between 1980 and 2000.

(iv) There is no expansion of Canada's gas pipeline system. The price of natural gas continues to be set at 85 percent Btu equivalence with oil. See the next section for relaxation of this assumption.

The reduction in Canada's oil consumption resulting from the higher oil price increases as opposed to a continuation of the $12.60/m^3$ ($2/bbl) annual increase of the late 1970s are substantial. Table 6 illustrates the possible savings for 1985, 1990 and 2000.[12]

We are forecasting that Canada could save approximately 29 Mm^3/d in 1985 (182 Mb/d) under the higher oil price forecast as opposed to the '70s Trend' forecast. (Refer to Appendix A for estimates of the implied price elasticities of this analysis.) This is a substantial saving especially if it is kept in mind that it represents more than the output of an oil sands plant at full capacity (20 Mm^3/d to 22 Mm^3/d). By the year 2000 the savings in oil consumption amount to 135 Mm^3/d.

Perhaps of greater significance are the accumulated savings in oil consumption if Canada reduced its growth rate in oil consumption from the recent historical rate of 2.5 percent to 1 percent. Comparing the '70s Trend' forecast to the 'higher oil price' forecast in terms of accumulated oil savings, Table 6 shows that over the 21 years 1980 to 2000 the total savings would be 479 MMm^3 (3,015 MMbbl). Canada's remaining established reserves as of the end of 1978 were 1090 MMm^3.[13] Savings in oil consumption of 479 MMm^3 represent approximately 45 percent of Canada's remaining established reserves as of the end of 1978. Looked at in this manner, the addition to Canada's supply of oil reserves in the year 2000 made possible by reduced rates of growth in oil consumption due to higher annual rates of oil price increases is certainly substantial.

TABLE 6

POSSIBLE SAVINGS IN OIL CONSUMPTION
THROUGH HIGHER OIL PRICE INCREASES
1985, 1990 AND 2000
(Mm^3/d)

1985 Oil Consumption		
a) '70s Trend' Forecast	349	
b) 'Higher Oil Price' Forecast	320	
1985 Oil Savings		29
1980-1985 Accumulated Savings		36 MMm^3
1990 Oil Consumption		
a) '70s Trend' Forecast	395	
b) 'Higher Oil Price' Forecast'	336	
1990 Oil Savings		59
1986-1990 Accumulated Savings		85 MMm^3
2000 Oil Consumption		
a) '70s Trend' Forecast	506	
b) 'Higher Oil Price' Forecast	371	
2000 Oil Savings		135
1991-2000 Accumulated Savings		358 MMm^3
1980-2000 Accumulated Savings		479 MMm^3

NOTES: The 1979 base is taken to be 301 Mm^3/d. The '70s Trend' forecast assumes a 2.5 percent average annual growth rate (AAGR) in oil consumption throughout the whole period 1979-2000.
For the assumptions to the 'Higher Oil Price' forecast see the note to Table 5.
See Table B.1 in Appendix B, which is this table reproduced in Mb/d.

NATURAL GAS PIPELINE EXPANSION

While the higher oil price increase in itself will lead to less oil consumption, there are other avenues through which Canada could reduce its oil consumption. The expansion of Canada's gas pipeline system is one such avenue.

Considerable expansion of Canada's natural gas pipeline system is likely to take place during the 1980s. The NEB concluded its hearing on the proposed gas pipeline into eastern Canada in February 1980. There seems to be a reasonable probability that this project will go ahead. Another gas pipeline project that will likely be approved during the 1980s is a pipeline to Vancouver Island.

In its November 1979 gas export report the NEB projected gas sales in new market areas in Canada. Included in this projection are expanded sales in Quebec, the Maritime provinces, Vancouver Island, Manitoba and Ontario. Table 7 shows the savings in oil consumption due to expanded natural gas sales. It is assumed that the additional gas sales, as forecast by the NEB, are totally at the expense of oil consumption.

TABLE 7

SAVINGS IN OIL CONSUMPTION DUE TO NATURAL GAS MARKET EXPANSION
(Mm^3/d)

1985	1990	2000
14	21	30

SOURCE: Canada, National Energy Board, Reasons for Decision, November 1979, Table C-5.

Greater oil consumption savings than those indicated in Table 7 are possible if production from the Sable Island area, Arctic Islands, or other east coast offshore areas takes place before the end of this century. At this time there is little reliable data on the cost and amount of gas reserves in these areas. In addition there is the possibility that more natural gas could be produced in Nova Scotia before the end of this century.

We now turn to a discussion of the oil savings possible through government legislated conservation measures.

GOVERNMENT LEGISLATED CONSERVATION PROGRAMS

Faced with higher energy prices, consumers may choose to curb their consumption of energy by some proportion depending on their sensitivity to price changes. Under some circumstances, however, consumers may not reduce their consumption even if it is the socially desirable response. Under such circumstances, consumers may be ill-informed or uninformed of the consequences of their behaviour and they may make decisions on the basis of this misinformation. A case in point would be the consumer who does not reinsulate his home because he does not know the value of the potential savings in his energy bill but rather only his immediate savings of choosing not to insulate.

In cases such as these, there needs to be another initiating force to inaugurate conservation practices. This is the role assigned to public policy. Policy measures designed to achieve conservation must be evaluated in the light of their cost-effectiveness to ensure that they do not overstep the bounds of economics. Cost effectiveness entails the assessment of the costs and benefits of an energy conserving measure to ensure it is exactly that--to ensure that two barrels of oil are not used in one sector of the economy to avoid consuming one barrel of oil in another sector. Policy makers must be careful in the adoption of supposedly energy conserving measures to ensure that the desired effect is also the realized effect. Administrative costs should also be considered in the evaluation of any conservation measure. If an energy conservation program costs more to administer than the value of the benefits earned by conserving the energy, the program is not cost-effective. In this regard governments must be careful to avoid the adoption of unwieldly conservation schemes which are a greater burden in terms of costs to society than the impinging cost of increased reliance on insecure energy imports.

Table 8 outlines several conservation schemes which have energy conservation potential for the Canadian economy. Estimates of the

TABLE 8

CONSERVATION PROGRAMS AND POSSIBLE ENERGY SAVINGS IN THE CANADIAN ECONOMY

Programs	Energy Savings Per Annum (10^{15} joules) by 1985	by 1990
In the Residential Sector: Reinsulation of existing homes	316	306
Adoption of improved energy efficiency standards for new homes		
Improved heating system efficiency, improved maintenance, retrofitting of existing furnaces, temperature set back		
In the Commercial Sector: The adoption of the three programs outlined above for the residential sector plus improved techniques in building operation and maintenance	316	443
In the Transportation Sector: Improved car performance standards	485	759
Inter-modal substitution		
Intra-modal substitution	___	___
Total Annual Energy Savings	1117	1508

SOURCE: Canada, Department of Energy Mines and Resources, Energy Conservation In Canada: Programs and Perspectives (Ottawa: Department of Energy Mines and Resources, 1977), Report EP 77-7.

energy savings to be achieved by each government program are difficult to ascertain and any estimates we do have are founded with an element of uncertainty. In this table we have adopted the energy conservation forecasts of the Department of Energy, Mines and Resources in their 1977 Energy Conservation report. This report was the only comprehensive quantitative analysis available. The timing of adoption of conservation measures, whether there is full or partial adoption of these measures, and whether they are legislated and enforced or there is more reliance on moral suasion will alter the forecasts. Our forecast assumes that governments legislate and enforce the full programs immediately.

In the residential sector there are three broad measures which account for the estimated annual energy saving of 306 x 10^{15} joules or 8 million cubic metres (MMm^3) of crude oil equivalent by 1990. Reinsulation of existing homes (under the Canadian Home Insulation Program), and the adoption of improved energy efficiency standards for new homes (through stricter building codes) as well as existing homes (through improved maintenance, retrofitting furnaces and temperature set back)[14] are the energy conservation measures contributing to the predicted energy saving in this sector. Extending these conservation measures into the commercial sector would result in an annual energy saving of 443 x 10^{15} joules or 11 MMm^3 of crude oil equivalent. The transportation sector appears to have a large energy saving potential with 759 x 10^{15} joules or 20 MMm^3 of crude oil equivalent by 1990. The program denoted 'intra-modal substitution' refers to energy savings coming from substituting among different types of road transport (i.e., increased use of car pools) as opposed to substituting between different modes of transport (i.e., rail for truck transport) which has been termed 'inter-modal substitution' in the context of Table 8.

By 1985, the estimated total energy saving across all three sectors is 1117 x 10^{15} joules or 29 MMm^3 of crude oil equivalent per year. By 1990, this energy saving is expected to increase to 1508 x 10^{15} joules or 39 MMm^3 of oil equivalent per year.

Worth noting from Table 8 is the absence of any conservation scheme expected to be implemented in the industrial sector. Over the forecast period (1980-2000) energy conservation in this sector is expected to occur as a result of the response to higher prices, but not as a result of the adoption of specific conservation measures per se. This is not a surprising result since industries, as profit maximizers, would find it in their best interests to respond as rapidly as possible to market signals such as higher prices. Industry is generally more responsive to changes in price than consumers as is evidenced by the relatively elastic (higher values) own-price elasticities reported in Table A.1 (presented in Appendix A) for the industrial sector. The estimated own-price elasticity for total energy in this sector ranged as high as -0.59 while the estimated elasticities for the residential and commercial sector were -0.32 and -0.31, respectively.

Since the prime objective of an energy self-sufficiency program for Canada would be to reduce this country's dependence upon oil imports, it is of consequence to determine the degree to which the conservation measures outlined in Table 8 would allow us to achieve this objective. The energy savings made possible by the conservation schemes outlined in Table 8 refer to 'total' energy savings. In order to see how these measures would promote self-sufficiency it is important to determine the proportion of these total energy savings which would be accounted for by reductions in crude oil consumption.

Using the forecast proportions of relative fuel shares (see Table 5 presented earlier) for the years 1985, 1990 and 2000, the proportion of total energy savings from Table 8 which could be expected to be accounted for by reductions in the demand for crude oil were calculated. The calculated savings in crude oil consumption are reported in Table 9.

TABLE 9

POSSIBLE SAVINGS IN CRUDE OIL
CONSUMPTION DUE TO CONSERVATION MEASURES
1985, 1990, 2000
(Mm^3/d)

1985	1990	2000
28	34	30

The estimated oil savings would be approximately 28 Mm^3/d for 1985, 34 Mm^3/d for 1990, and 30 Mm^3/d for 2000.

The crude oil savings shown in Table 9 must be considered as rough estimates as the impact of government legislated conservation measures is particularly difficult to forecast. The figures in Table 9 are best viewed as an assessment of possible crude oil savings within the context of an assumed economic, social and technological framework.[15]

It would appear that the ability of energy conservation programs to reduce crude oil consumption is substantial. In the first five years of the forecast period crude oil savings due to government legislated conservation measures will have reached 28 Mm^3/d which is greater than the combined output of the Syncrude and Great Canadian Oil Sands (GCOS) plants at their current levels of production. Viewed alternatively, these savings have the potential of reducing our current level of oil imports (approximately 79 Mb/d) by approximately 35 percent. This potential ability to back out imports, of course, is dependent upon the ability of the transportation system to move more crude oil to Quebec and the Maritime provinces.

By 1990, crude oil savings due to the government legislated conservation measures considered in this paper will have reached its maximum level of 34 Mm^3/d declining thereafter to 30 Mm^3/d by the year 2000. As these conservation measures are introduced crude oil savings are realized which are large at first, growing for a period and then declining.

Comparing the oil savings made possible by specific conservation measures (see Table 9), higher oil prices (see Table 6), and the expansion of the gas pipeline system (see Table 7), it is worth noting that a large saving potential in the earlier years lies with conservation. The largest crude oil saving potential, however, rests with higher oil price increases in the latter part of the forecast period. This is because the results of conservation programs are fairly immediate but there are time lags in the area of price response. In the year 2000, higher oil prices account for crude oil savings of 135 Mm^3/d, compared to 30 Mm^3/d for conservation. Thus, as consumers have time to adjust to the higher prices for crude oil, savings are realized. This adjustment may be expected to take a considerable period of time for it requires changes in life styles, attitudes and institutional factors which are all characterized by their resistance to change.

SUMMARY AND CONCLUSION

Table 10 shows possible savings in oil consumption due to higher oil prices, gas pipeline expansion and government legislated conservation measures. In total, Canada could save about 71 Mm^3/d of crude oil in 1985, rising to 195 Mm^3/d in 2000. The saving of 71 Mm^3/d by 1985 depends substantially on government legislated conservation measures, of which there is considerable uncertainty as to both their probability of being legislated and their impact. We believe the total savings estimate of 71 Mm^3/d in 1985 to be optimistic viewed in the light of the uncertainty surrounding the possibility of governments legislating such conservation measures. In the later years these measures comprise a smaller proportion of total crude oil savings and, for this reason, we believe that in the later years (1990 and 2000) there is less upward bias from possible over optimism in the area of conservation measures.

Figure 1 shows levels of Canadian oil consumption forecast under the different assumptions made in this paper regarding various prospects for oil savings. The numbers in brackets show average annual growth rates (AAGR) from 1979. The '70s Trend' forecast shows oil consumption growing at an AAGR of 2.5 percent to 2000. The impact of higher oil prices is forecast to reduce the growth rate to 1 percent. Adding expansion of natural gas pipelines reduces the average annual growth rate estimate to 0.6 percent. Finally, if we add the forecast savings from government legislated conservation measures in 2000 (i.e., 30 Mm^3/d), the overall growth rate in oil consumption is reduced to 0.2 percent.

Looking at the intermediate year 1990, the combined impact of higher oil prices and gas pipeline expansion is forecast to bring the growth rate down from 2.5 percent under the '70s Trend' forecast to approximately 0.5 percent. The addition of government conservation

TABLE 10

SAVINGS IN CANADIAN OIL CONSUMPTION
1985, 1990, 2000
(Mm^3/d)

Year	Impact of Higher Oil Prices[a]	Expansion of Gas Pipeline System[b]	Government Legislated Conservation Measures[c]	Total
1985	29	14	28	71
1990	59	21	34	114
2000	135	30	30	195

[a]See Table 6.
[b]See Table 7
[c]See Table 9.

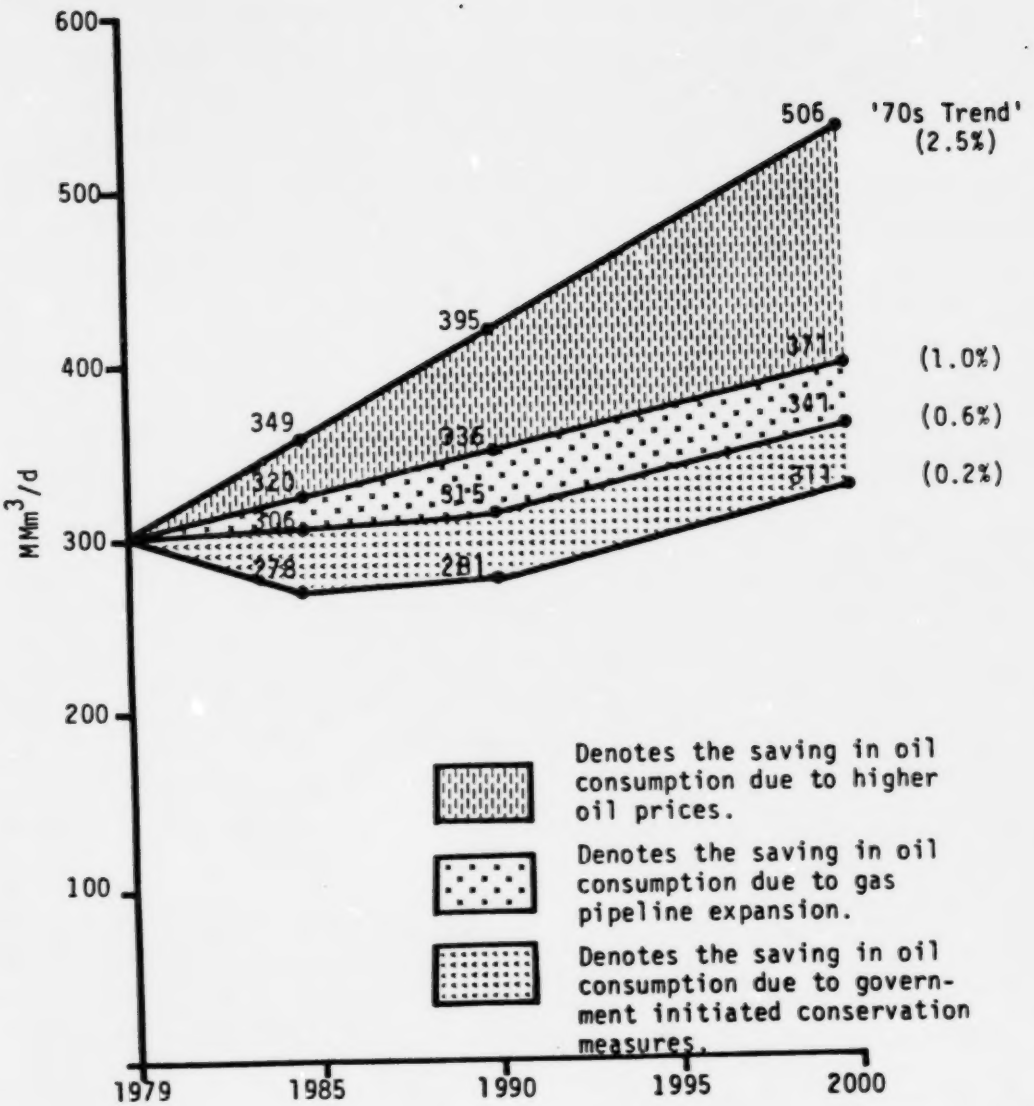


FIGURE 1: FORECAST LEVELS OF OIL CONSUMPTION, 1979-2000

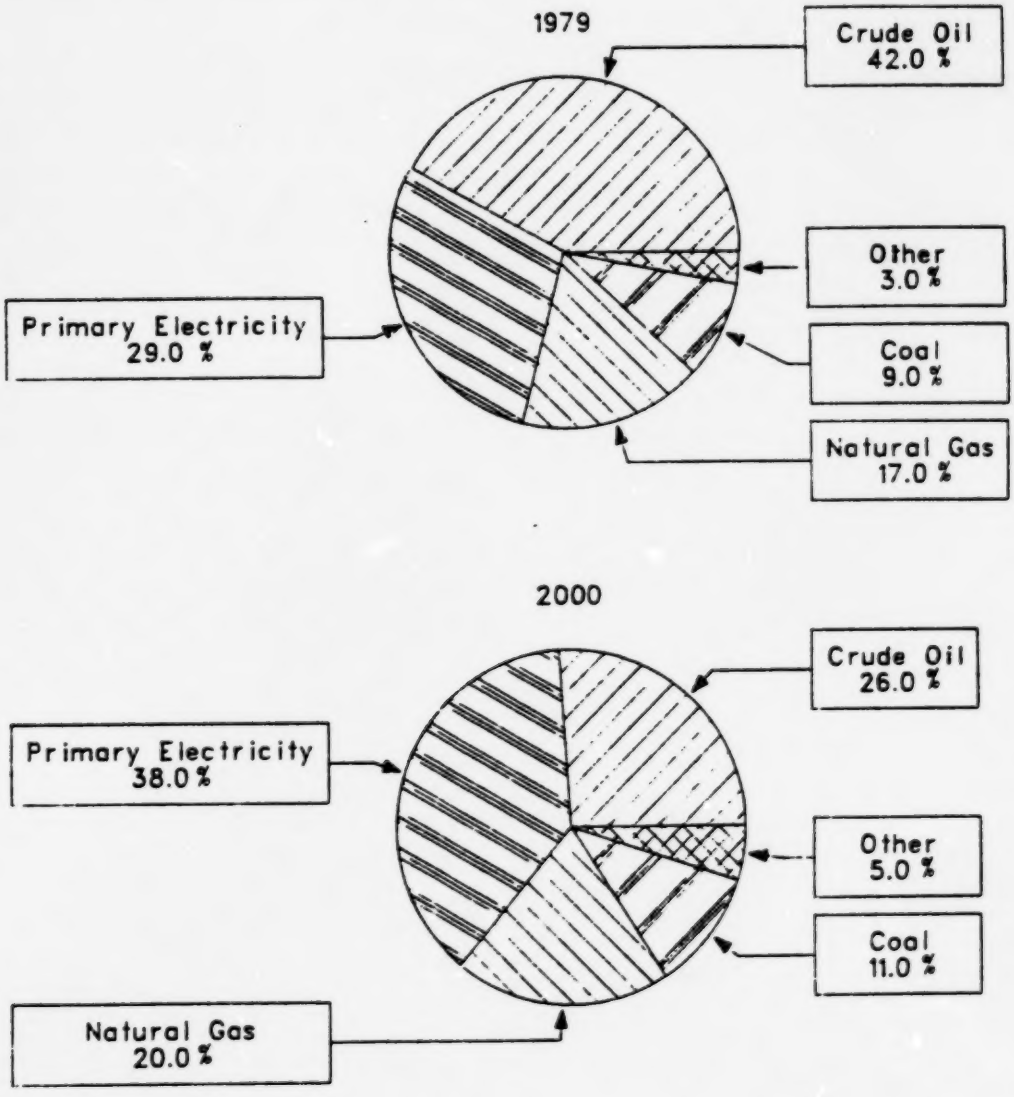
NOTE: The percentage figures in brackets denote the average annual growth rates for oil consumption under the various scenarios for the period 1979 to 2000.

measures could result in 1990 oil consumption being less than 1979 consumption, resulting in a negative growth rate over the eleven years.

Figure 2 shows the relative fuel shares in 1979 as reported by the NEB in its November 1979 Reasons for Decision gas export report and our forecast of fuel shares in 2000 assuming higher oil prices, gas pipeline expansion and government legislated conservation measures.[16] Oil is forecast to account for 26 percent of total energy consumption in 2000 compared to about 42 percent at present.[17]

It is important that Canada allows its domestic oil price to increase at a rate considerably above $\$12.60/m^3$ per year if oil is to account for 26 percent of total energy consumption in 2000. The relative importance of higher oil prices in contributing to lower growth in oil consumption is evident from Figure 1.

We believe the price mechanism is an efficient allocator of Canada's scarce oil reserves and is a mechanism upon which considerable reliance should be placed before legislating specific measures designed to reduce oil consumption. A higher oil price has the dual advantage of increasing domestic supply while restricting domestic demand.[18] The net result is less dependence on imported oil and thus a step towards energy self-sufficiency.



1979: National Energy Board, Gas Export Report. November 1979, Table C-5.
2000: Consideration has been given to 1) higher oil prices, 2) gas pipeline expansion, and 3) government initiated conservation measures as discussed in this paper.

FIGURE 2: Relative Fuel Shares, 1979 and 2000.

Footnotes

[1]Imports currently account for about 25 percent of Canada's oil requirements.

[2]A companion paper by Z. Charles Slagorsky "Alternative Future Supplies of Oil in Canada and their Costs" (Calgary: Canadian Energy Research Institute, May, 1980), Working Paper 80-3, analyzes Canada's prospects for increased oil production.

[3]1979 estimate from Oilweek, April 21, 1980, p. 14.

[4]The own-price elasticity of demand equals:

$$\frac{\% \text{ change in quantity of good demanded}}{\% \text{ change in price of good}}$$

The own-price elasticity shows the percentage change in the quantity of the good demanded given a one percent change in its price.

[5]There is presently (April 1980) some surplus capacity in world oil markets. This excess capacity will soon be eroded by growing world demand if new and large sources of supply are not made available.

[6]The NEB and EMR forecasts shown in Table 3 assume parity with world oil prices by 1983 and 1986 respectively. Given that imports currently cost about $\$220/m^3$ ($35/bbl) and the domestic price is about $\$93/m^3$ ($14.75/bbl), a domestic price increasing at $\$31/m^3$ ($5.00/bbl) per year in combination with the import price increasing at 11 percent per year (2 percent above Canada's rate of inflation) would never result in parity but rather a further widening of the two prices.

[7]W. Brent Friedenberg, Energy in Canada: Review and Outlook to 1995 (Calgary: Canadian Energy Research Institute, July 1979), Study No. 5.

[8]Given the current difference between domestic and world oil prices, it is highly unlikely Canada's domestic price will achieve parity with world oil prices during the early part of this decade. See footnote No. 6.

[9]The NEB in its November 1979 Reasons for Decision report assumed real GNP to grow at an average annual rate of 3.6 percent between 1979 and 1989, and 3.4 percent between 1990 and 2000. The EMR assumes a growth rate for real GNP that averages 3.73 percent between 1978-2000. (See Canada, Department of Energy, Mines & Resources, Canadian Oil and Gas Supply/Demand Overview (Ottawa: Supply & Services, November 1979).

[10]The NEB in its November 1979 gas export report forecast oil consumption to account for 31 percent of total primary energy consumption in 2000 (medium demand case). This figure agrees with that produced by EMR under the '1986 Parity' case. Friedenberg's study for the Canadian Energy Research Institute forecasts oil consumption to account for 29 percent of Canada's primary energy consumption in 1995.

[11]Referring to the above footnote (f.n. 10) the comparable percentage figures between NEB, EMR, and Friedenberg are 38, 37 and 37 percent respectively for primary electricity.

[12]Throughout this paper the term 'savings in oil consumption' is used in place of the term 'reduction in oil consumption'. Since oil is a depletable natural resource a reduction in oil consumption today has the effect of saving oil for future consumption.

[13]Canadian Petroleum Association, Statistical Handbook (Calgary: Canadian Petroleum Association, 1979).

[14]The required temperature set back to achieve the energy savings estimated under this program would be 18°C at night and 21°C during the day.

[15]This 'framework' is the same as that assumed by Canada, Department of Energy Mines and Resources, An Energy Strategy for Canada: Policies for Self-Reliance (Ottawa: Department of Energy, Mines and Resources, 1976).

[16]We expect the demand for total energy to grow at an average annual rate of 2.5 percent over the period 1980 - 2000.

[17]The projections contained in this paper make no allowance for the possibility of consuming oil derived from coal liquifaction. To the extent this becomes possible before the year 2000 there will be savings in Canada's consumption of conventional oil reserves. Coal liquifaction is becoming a stronger possibility as oil prices continue to rise.

[18]Implicit in this statement is that higher revenues are realized by producers, and consumers are not subsidized to the extent of the price increase.

APPENDIX A:

ESTIMATES OF PRICE ELASTICITIES BY FUEL TYPE AND END USE SECTOR

The most important vehicle through which changing market circumstances are translated is the price mechanism. The measuring device which reveals consumer sensitivity to changes in the price of a particular commodity is called the 'own-price' elasticity. The lower the absolute value of the own-price elasticity measure, the less responsive is demand to changes in price.

Table A.1 reports estimates, and in some cases a range of estimates, for own-price elasticities for individual fuel types and total energy in each end-use consuming sector. These estimates were collected from a variety of sources and in some instances there were no reported elasticities. Different end-use sectors have varying responses to higher energy prices, as is verified by this table. Sectors in which there are large substitution possibilities or inefficient uses of energy are expected to be the most responsive to energy price changes. The industrial sector is generally viewed in this manner and a glance across the row in Table A.1 for the industrial sector reveals that estimates of own-price elasticity generally verify this response. The transportation sector, on the other hand, has a very limited range of substitution possibilities since it is heavily oriented towards the consumption of fossil fuels and more specifically motor gasoline and diesel oil. For this reason, this sector is expected to be much less responsive to price changes in the short run. Energy savings which emanate from this sector are expected to be largely dependent upon technological advances and are, therefore, long-run savings.

TABLE A.1

ESTIMATED OWN-PRICE ELASTICITIES BY FUEL TYPE AND END-USE SECTOR

	Motor Gasoline	Fuel Oil	Diesel	Electricity	Coal	Natural Gas	LPG	Total Fossil Fuels	Total Energy
Residential				-0.14		-0.6 to -0.15		-0.7	-0.32
Commercial				-0.31					-0.31
Industrial	-1.6	-1.3			-1.5 to -4.2	-1.3 to -2.2	-2.4		-0.30 to -0.59
Transportation	-0.18 to -0.45		-1.26						

SOURCES: Canada, Department of Energy Mines and Resources, Energy Demand Projection, A Total Energy Approach (Ottawa: Supply and Services, 1977), Report ER 77-4.
E.R. Berndt, "Canadian Energy Demand and Economic Growth", in Oil in the Seventies (Vancouver: The Fraser Institute, 1977).

Two additional important points concerning Table A.1 need to be made. The first point is the large range of elasticities reported for coal usage in the industrial sector. A 1964 cross section study estimated own-price elasticity to be -4.2 which reveals for that year coal consumption was very responsive to changes in price.[1] The lower estimate of -1.5 was a result of a time series analysis which evidenced that over time consumers of coal in the industrial sector are becoming less responsive to changes in price, perhaps as the inefficiencies in consumption are eliminated. The second point is that the estimate for own-price elasticity for natural gas combined the two end-use sectors: residential and commercial. This was done because of reporting difficulties in separating those two sectors.

The last column of Table A.1 reports estimates of own-price elasticity for total energy. These estimates are generally less than the estimates of own-price elasticity for specific fuel types. This observation is rationalized on the grounds that there are more substitution possibilities among fuel types than for energy per se.

In the present paper, the implied point own-price elasticities corresponding to the 'higher oil price' forecast were approximately -0.11 in each year (1980, 1985, 1990 and 2000). Implied consumer response to higher oil prices is relatively low, with a 1 percent change in the price of crude oil reducing crude oil demand by only 0.11 percent. The reason for the significant oil savings in the 'higher oil price' forecast is because price has changed significantly, moving us a long way up the demand curve.

---

[1]James A. Coombs, "A Cross-Sectional Study of Energy Demand in Canadian Manufacturing Industries, 1964" (Master of Arts Thesis, Department of Economics, Queen's University, September 1969).

APPENDIX B

TABLE B.1

POSSIBLE SAVINGS IN OIL CONSUMPTION
THROUGH HIGHER OIL PRICE INCREASES
1985, 1990 AND 2000
(Mb/d)

1985 Oil Consumption		
a) '70s Trend' Forecast	2,196	
b) 'Higher Oil Price' Forecast	2,014	
1985 Oil Savings		182
1980-1985 Accumulated Savings		227 MMbbl
1990 Oil Consumption		
a) '70s Trend' Forecast	2,486	
b) 'Higher Oil Price' Forecast'	2,114	
1990 Oil Savings		372
1986-1990 Accumulated Savings		535 MMbbl
2000 Oil Consumption		
a) '70s Trend' Forecast	3,184	
b) 'Higher Oil Price' Forecast	2,335	
2000 Oil Savings		849
1991-2000 Accumulated Savings		2,253 MMbbl
1980-2000 Accumulated Savings		3,015 MMbbl

NOTES: The 1979 base is taken to be 1,894 Mb/d.

The '70s Trend' forecast assumes a 2.5 percent average annual growth rate (AAGR) in oil consumption throughout the whole period 1979-2000.

For the assumptions to the 'Higher Oil Price' forecast see the note to Table 5.